THIN COATED ADSORBENT LAYER ON FIN SYSTEM FOR METHYLENE BLUE DYE REMOVAL

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THIN COATED ADSORBENT LAYER ON FIN SYSTEM FOR METHYLENE BLUE DYE REMOVAL

by

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LIST OF SYMBOLS

K_L	Langmuir constant (L mg^{-1})
q_{max}	Monolayer adsorption capacity of the adsorbent (mg g^{-1})
k_f	Freundlich isotherm constant (mg g^{-1}) (L mg^{-1})$^{1/n}$
n	Adsorption intensity
R^2	Correlation coefficient
q_e	Maximum adsorption capacity of adsorbent (mg g^{-1})
C_i	Initial concentration of the solution (mg L^{-1})
C_f	Final concentration of solution (mg L^{-1})
m_b	Mass of bentonite (g)
C_e	Equilibrium concentration of adsorbate (mg L^{-1})
R	Percentage removal (%)
C_t	Concentration at time (mg L^{-1})
m_p	Mass of water-based paint (g)
m_w	Mass of water (g)
m_t	Total mass of *Paintosorp*^{TM} (g)
S	Total surface area (m^2)
l	Length of fin contacted with the dye solution (m)
w	Width of fin contacted with the dye solution (m)
m_f	Mass of *Paintosorp*^{TM} on fin (g)
n_f	Number of fin needed
T	Time removal of dye (h)
ε	Percentage error (%)

LIST OF ABBREVIATIONS

BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
SS	Suspended solids
ADMI	American dye manufacturers institute
MB	Methylene blue dye
BET	Brunauer-Emmett-Teller (BET)
AOPSC	Acid treated oil palm shell charcoal
FTIR	Fourier Transform Infrared Spectroscopy
TGA	Thermogravimetric analysis
DSC	Differential scanning calorimetry
XRD	X-ray powder diffraction
BF	Basic fuchsin
CV	Crystal violet
IMK	Iron-manganese oxide coated kaolinite
XRS	X-ray spectrometer
EDX	Energy Dispersive X-Ray Spectroscopy
SEM	Scanning electron microscope
XRF	X-ray fluorescence
UV-Vis	Ultra-violet spectrophotometer

LAPISAN PENJERAP NIPIS PADA SISTEM SIRIP UNTUK MENYINGKIRKAN PEWARNA METILENA BIRU

ABSTRAK

Lapisan penjerap nipis (*Paintosorp*^{TM}) telah direka bentuk untuk menyingkirkan pewarna kationik daripada air sisa industry menggunakan sistem sirip yang merupakan sebuah teknik aplikasi penjerapan baru. Rawatan terkini menggunakan karbon aktif memerlukan bajet yang tinggi untuk proses pemasangan ruangan karbon and kos yang tinggi untuk penjanaan semula. Oleh yang demikian, sistem sirip mempunyai keupayaan untuk menggantikan unit rawatan konvensional yang mahal yang kebanyakannya digunakan dalam industri. Tujuan kajian ini dijalankan adalah untuk mengkaji permukaan yang sesuai untuk disaluti oleh *Paintosorp*^{TM} dan membangunkan persamaan matematik yang mudah untuk sistem sirip dengan menggunakan bentonit sebagai bahan penjerap yang disokong. Dengan adanya persamaan matematik tersebut dengan mudah dapat digunakan untuk menghitung keperluan salutan dalam merawat efluen tekstil. Dengan memasang sirip bersalut penjerap di dalam tangki, kepekatan warna dapat dikurangkan sehingga 90%. *Paintosorp*^{TM} didapati tahan kepada suhu dan air serta boleh disalut di atas banyak permukaan. Parameter fiziko-kimia seperti kesan kepekatan warna (metilena biru), ketebalan bahan penjerap, kawasan permukaan, jarak antara sirip dan kadar pencampuran telah dikaji untuk penjerapan optimum pewarna terhadap *Paintosorp*^{TM}. Ketebalan penjerap terbaik dan permukaan kawasan untuk penjerapan optimum pewarna (277.8 mg g^{-1}) pada *Paintosorp*^{TM} ditemui 87 µm dan 112 cm^2. Data penjerapan keseimbangan mewakili isoterma Langmuir menunjukkan penjerapan berlaku di permukaan homogen dan dalam keadaan satu lapisan. Formula

matematik yang dibangunkan daripada model isoterma penjerapan telah terbukti dapat digunakan dalam aplikasi berskala besar kerana kesalahan peratusan antara nilai kiraan and eksperimen adalah kurang daripada 18 %.

THIN COATED ADSORBENT LAYER ON FIN SYSTEM FOR METHYLENE BLUE DYE REMOVAL

ABSTRACT

An innovative cost effective thin coated adsorbent layer (*Paintosorp*^{TM}) has been designed for removing cationic dye from industrial wastewater by using fin system as a new adsorption application technique. The current treatment using activated carbon requires high budget allocation for installation unit of carbon column and high cost for regeneration. Thus, fin system has ability to replace expensive conventional adsorption treatment units that mostly used in industries. The aims of this study are to find the suitable material to be coated with *Paintosorp*^{TM} and to develop simple mathematical equations for fin's system using bentonite as a supported adsorbent. These simple mathematical equations can be easily applied to enumerate coating requirement in treating textile effluent. By installing coated fins inside tank, the concentration of dye can be easily reduced up to 90%. The *Paintosorp*^{TM} is found resistant to temperature and water and easily coated on many surfaces. The physico-chemical parameter such as effect of dye concentration (Methylene Blue), adsorbent thickness, surface area, fin spacing, and mixing rate has been studied for the optimum adsorption of dye on the *Paintosorp*^{TM}. The best adsorbent thickness and surface area for the optimal adsorption of dye (277.8 mg g^{-1}) on *Paintosorp*^{TM} was found as 87 µm and 112 cm^2, respectively. The equilibrium adsorption data was best fitted by the Langmuir isotherm, indicating the adsorption is homogeneous surface and in monolayer state. The mathematical formula derived from isotherm model of adsorption was revealed to be used in large scale application

since the percentage error between calculation and experimental value was less than 18 %.

CHAPTER ONE

INTRODUCTION

1.1 Water pollution

Generally, water covers over 70 percents of the earth surfaces and it becomes an important resource for people and environment (Love & Luchsinger, 2014). Water is colorless, tasteless and odorless substance that is essential in our life. Besides, water is a unique substance that can renew and clean itself naturally through the sedimentation process. In the process, the pollutants are allowing to settle out by diluting them to the low concentrations that is not harmful (Yazdi, 2012). However, this natural process takes time and it becomes difficult if there are excessive quantities of harmful contaminants are added into water. Nowadays, the demand of water is becoming greater due to the growing world population but this natural resource has become scarce and its availability is a major concern among societies.

Water pollution has become a serious environmental threat around the world owing to rapid industrialization and urbanization (Cui & Shi, 2012; Man et al., 2015). In recent years, it is recognized as one of the serious problems existed all over the world. It is caused by the addition of chemical and biological substances in certain concentrations either naturally or man-made to the natural water bodies. By referring to the Malaysia environment status report (DOE, 2010), the number of problems of water pollution caused by sewage treatment plants at year 2006 to 2010 increased from 9, 060 to 10, 025 whereas manufacturing industries increased from 8, 534 to 9, 069 (Pang & Abdullah, 2013).

Dye wastewater consists of a number of contaminants including acids, bases, dissolved solids, toxic compounds and colour. Coloured wastewater is a consequence of batch processes both in dye manufacturing industries and in the dye-consuming industries. In fact, industries such as dyestuff, textile, paper, leather, foodstuffs, cosmetics, rubber and plastics are using large amount of synthetic dyes in order to give colour for their products. Unfortunately, the colour compounds can react with metal ions to form substances that are very toxic to aquatic flora and fauna and also cause water borne diseases (Vijayakumar et al., 2012). The discharge of highly coloured wastewater into environment is not only aesthetically displeasing, but impedes light penetration, thus upsetting the biological processes within the rivers, ponds and lakes. Textile and dyeing industry are among important sources that contributing to the water pollution since the percentage of dye lost in wastewater is found about 50 % of total dyes used due to the low levels of dye-fibres fixation (Janet et al., 2015).

1.2 Textile industry in Malaysia

Textile manufacturing in Malaysia is a well known as the fastest promising industries that assists the profitable growth especially in Kelantan and Terengganu (Pang & Abdullah, 2013). Malaysia has produced about 40,000 tons of man-made fibers which are made up of polyester filament, nylon and staple in 2008. The growth of Malaysia’s textiles and apparel industry accelerated in the early 1970s and these industries comprises four sub sectors, namely primary textiles which cover activities such as polymerisation, spinning, weaving, knitting and wet processing; made-up garments; made-up textiles; and textile accessories. According to Malaysia Investment Development Authority (MIDA), Malaysia was the ninth largest producer and exporter of textile products to the top five destinations such as USA, Japan, Indonesia, Turkey and the People's Republic of China in 2013 (MIDA, 2015).

Textile industries become the worst offenders of water pollution since these industries use more than 2,000 types of chemicals and over 7,000 types of dyes (Muslim & Rohasliney, 2015). In fact, more than 3600 individual textile dyes are being manufactured by the industry today and they are using more than 8000 chemicals in various processes of textile manufacture including dyeing and printing (Bhatt & Rani, 2013). Figure 1.1 shows the percentage number of water pollution in several countries in Malaysia. It is clearly shows that the major source of water pollution comes from textile industry that are located in Peninsular Malaysia. Johor, Pulau Pinang and Selangor have the highest percentages in contribution of water pollution source as compared to other countries which is 28.6 %, 28.2 % and 15.6 % respectively.

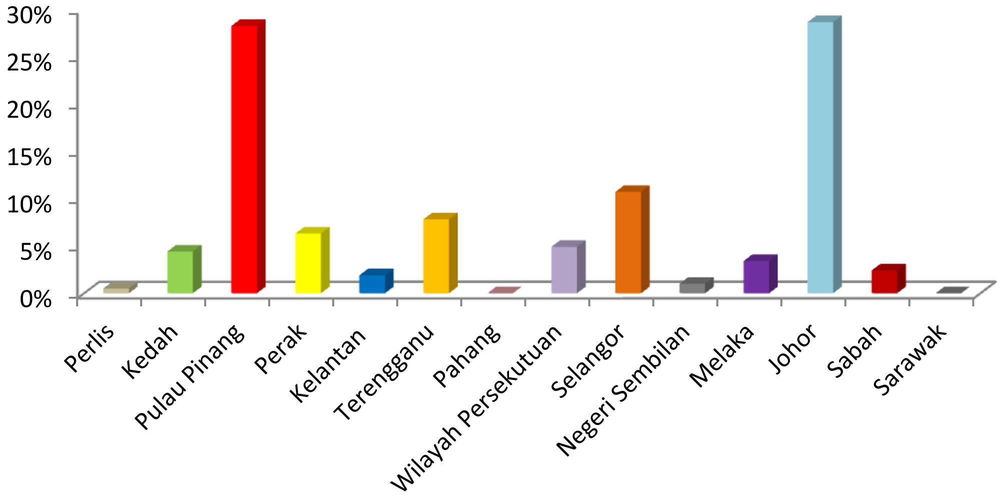

Figure 1.1: Contribution of textile industry to water pollution for different states in Malaysia (Pang & Abdullah, 2013)

1.3 Source of textile industry water pollution

Generally, the water pollution in textile industry comes from various process stages include pre-treatment, dyeing, printing and finishing of textile materials. These processes utilize large quantity of water which finally become wastewater. At pre-treatment stages, the wastewater generated from desizing process has been contributed to the largest source of pollution. Desizing is a process to remove the sizes that have been attached to the yarns during weaving process. This is because, during desizing process, all the sizes used during weaving are removed from the fabric and discarded into the wastewater (CETeDDD, 2014).

Scouring is the process of removing impurities. In scouring process, the dirt, oil and waxes from natural fibers are removed from the fabric and washed into wastewater stream using scouring agents such as detergents, soaps, and various assisting agents such as alkalis, wetting agents, defoamers and lubricants. After scouring process, the goods are thoroughly rinsed in water in order to remove excess agents. Normally, the process of desizing and scouring are combined together. These two processes contribute up to 50 % of total BOD in the wastewater during wet processing (CETeDDD, 2014).

Bleaching is a process to remove natural colouring from cotton, blend fabrics or yarn and is sometimes required on wool and some synthetic fibres. The sodium hypochlorite and sodium chlorite bleaching are the most commonly used in textile making processes. The aim of mercerising process are to improve strength, lustre and dye affinity of cotton fabrics. A cold sodium hydroxide is applied then causes the fibers to swell and adopt a circular cross section (CETeDDD, 2014).

Dyeing is the process in which the colours were applied to the textile substrate mainly using synthetic organic dyes at elevated temperatures and pressures. During this process, dyes and chemical aids include surfactants, acids, alkali/bases, electrolytes, carriers, levelling agents, promoting agents, chelating agents, emulsifying oils, softening agents and others are applied to the textile to get the uniform depth of colour with the colour fastness properties that suitable for the end use of the fabric. The process takes place in dyeing includes diffusion of the dye into the liquid phase followed by adsorption onto the outer surface of the fibers and finally diffusion and adsorption on the inner surface of the fibers. In addition, different fastness properties may be required depending on the expected end use of the fabrics. Dyeing wastewater is generate the largest portion of the total wastewater that produced from the dye preparation, spent dye bath and washing processes. Dyeing wastewater contains high salt, alkalinity and colour (CETeDDD, 2014).

Finishing process is the final stage in textile manufacturing to improve the quality of the fabric like water proofing, fire resistance and others by involves treatments with chemical compounds. The examples of fabric treatments applied in finishing processes include permanent press treatment, water proofing, softening, antistatic protection, soil resistance, stain release and microbial or fungal protection. Nevertheless, this process generates organic pollutants such as residue of resins, softeners and other auxiliaries (CETeDDD, 2014). Pollutants at various stages of manufacturing of textile are presented in Figure 1.2.